R E P O R T R E S U M E S

ED 016 401 56 EM 005 986

SELF-DIRECTION IN PROGRAMED INSTRUCTION--EFFECTS ON LEARNING IN LOW-ABILITY STUDENTS.

BY- BIVENS, LYLE W. AND OTHERS
AMERICAN INST. FOR RESEARCH IN BEHAVIORAL SCIENCES

REPORT NUMBER AIR-D10-7-63-TR PUB DATE JUL 63
REPORT NUMBER NDEA-VIIA-946
GRANT OEG-7-48-0000-183
EDRS PRICE MF-$0.25 HC-$2.00 48P.

DESCRIPTORS- *PROGRAMED INSTRUCTION, ANALYSIS OF VARIANCE, *INDEPENDENT STUDY, *LOW ABILITY STUDENTS, *QUESTIONNAIRES, *RETENTION, ACHIEVEMENT TESTS, LINEAR PROGRAMING, SET THEORY, GRADE 9, EXPERIMENTS

TWO GRADE 9 MATH CLASSES (41 STUDENTS) OF LOW ABILITY WERE EACH EXPOSED TO LINEAR AND SELF-DIRECTED (COMPLETE FREEDOM AS TO EXTENT, SEQUENCE, AND METHOD OF STUDY) PROGRAMS ON SET THEORY AND PERMUTATIONS. ANALYSIS OF VARIANCE FOR ACHIEVEMENT TEST SCORES AND MEAN RETENTION SCORES SHOWED NO SIGNIFICANT EFFECT OF PROGRAM TYPE OF STUDY TIME. QUESTIONNAIRE DATA SHOWED, IN PART, A SIGNIFICANT PREFERENCE FOR THE LINEAR PROGRAM. THE AUTHORS POINT OUT THAT SELF-DIRECTION DID NOT AFFECT PERFORMANCE ADVERSELY. (LH)

OFFICIAL FILE COPY VII #946 A
EM 005 986
AIR-D10-7/63-TR PA 56
ED 016401

SELF-DIRECTION IN PROGRAMED INSTRUCTION: EFFECTS ON LEARNING IN LOW-ABILITY STUDENTS

Lyle W. Bivens
Vincent N. Campbell
Donald F. Terry

July 1963

U. S. Office of Education
Department of Health, Education, and Welfare

American Institute for Research

AMERICAN INSTITUTE FOR RESEARCH

mailing address: Station A, P.O. Box 11487, Palo Alto, Calif.
Telephone 321-2130 (Area Code 415)
office location: 1791 Arastradero Road, Palo Alto, California

SELF-DIRECTION IN PROGRAMED INSTRUCTION: EFFECTS ON LEARNING IN LOW-ABILITY STUDENTS

Lyle W. Bivens

Vincent N. Campbell

Donald F. Terry

AIR-D10-7/63-TR

Technical Report

Grant No.: Title VII 7-48-0000-183

Leslie J. Briggs, Principal Investigator

July 1963

U. S. Office of Education

Department of Health, Education, and Welfare

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

EM 005 986

ACKNOWLEDGEMENTS

The study described in this report was made possible through the cooperation of Mr. T. F. Reynolds, Superintendent, and Dr. M. H. Winward, Assistant Superintendent, San Mateo Union High School District, and Dr. Paul R. Bowers, Principal, San Mateo High School. The authors are indebted to Mr. V. Mayers of San Mateo High School, California, for administration of materials and his many helpful suggestions during the course of the research.

SELF-DIRECTION IN PROGRAMED INSTRUCTION: EFFECTS ON LEARNING IN LOW-ABILITY STUDENTS

One of the dimensions along which instructional methods may vary is the degree to which the student directs and controls the learning process. At one extreme of this dimension is the small-step linear program which dictates a specific sequence and method of study for all students. The opposite extreme can be characterized by giving the student a list of learning objectives to be attained and then permitting him to proceed to learn the required behavior using any method or sources that he desires. Typically, teaching methods in secondary schools fall between these two extremes, not necessarily because some compromise appears to be the best method for all students, but because the nature of materials used in the classroom, the teachers' time and scheduling requirements lend themselves to some combination of these extremes. In fact, the extent of self-direction that should be permitted or encouraged in any population of students remains open to question.

At first glance, one can think of several reasons why permitting a student to assume more control over his own learning should be valuable: (a) the feeling of increased responsibility may be a motivating factor in itself (b) it appears reasonable that in some ways the student, rather than the teacher, may be the better judge of the student's progress toward a clearly-defined objective (c) self-direction may permit a student more flexibility in adjusting his study method and procedure to suit his own temperament and personality characteristics (d) the amount of guidance and direction customarily given students may be more than is actually required. More flexibility in choice and administration of learning materials may free the teacher of much routine labor and permit him to spend more time on activities such as individual instruction and coaching.

This experiment was an initial attempt to assess the effects of self-direction and self-evaluation on learning of mathematical topics. Although the value of student control techniques may vary with ability,

this study concentrated upon the effects of such techniques with students of low ability. It was of considerable interest to see if such a population of students was able to effectively organize and direct their own study. In addition to performance measures of learning, student preferences for teaching method (self-directed vs. linear) were assessed and analyzed in relation to the performance measures.

Method

Subjects

Ss in this experiment were two ninth-grade general mathematics classes. Both classes were considered by school personnel to represent the lower half of the mathematical achievement distribution for ninth-grade students. The two classes comprised a total of 41 Ss.

Material

Program Formats. Two learning programs were used, one program on permutations and combinations (Campbell & Terry, 1962) and the other on elementary set theory (Campbell, Terry, & Shearer, 1962). Both programs were modified into two forms: a linear form and a self-directed form. Both forms consisted of basic text, examples and explanations, and self-test items all in booklet format. Correct answers to self-test items, and to the occasional responses called for in the other materials, always appeared on the following page.

In the linear form, all of these components were integrated into a single orderly step-by-step sequence and students were required to proceed through the program page-by-page, answering all questions and reading all of the material.

In the self-directed form, the three components (text, examples and explanations, and self-test items) were color coded and kept physically separate, but were clearly identified as to their nature and were cross-indexed to each other. Under the self-directed condition Ss were instructed to go through the program in any manner they wished. Overt responses to self-test items were not required nor were students required to read all the material. Ss had complete freedom, as to extent, sequence, or method of study.

In addition to the program materials, both the linear and self-directed groups had an outline of key concepts which was indexed to the

other learning materials. Under self-directed conditions, Ss were permitted to refer to the outline throughout the program but Ss under linear conditions used the outline only for review after completing the program. Both the linear and self-directed programs were self paced.

Questionnaire. A questionnaire was developed in order to assess Ss' preference for teaching method and to determine how Ss under the two learning conditions went about the learning task. This questionnaire was administered twice: once after Ss had completed each of the programs. Item 1 of the questionnaire asked Ss in both linear and self-directed conditions to rate the lesson in terms of how much they enjoyed studying it. Item 2 asked Ss if they would be interested in learning more about the material they had just finished studying. Other questionnaire items asked Ss how they used the various materials and what their general procedure was. After Ss had had experience with both linear and self-directed conditions, they were asked to compare the two methods of programing in the final questionnaire (see appendix A for questionnaires).

Procedure and Design

The permutations and combinations program was given to Ss first. Linear programs were given to Class I (N = 18) and self-directed programs given to Class II (N = 23). Programs were distributed and instructions given by the regular mathematics teacher. In the linear condition S took a criterion test after he had completed the program and had briefly reviewed it using the outline as a guide. In the self-directed condition S took the test whenever he felt ready for it. The 51 criterion test items were heterogeneous in nature and covered all of the major points in the program. Under either condition, Ss were told that if they failed to obtain a score of 75% on the test, they would have to study the program some more under the same condition (self-directed or linear). In repeating the program in the linear condition S was allowed to skip any page he felt he knew. Ss were permitted to take the criterion test as many times as they wanted. A record of the time that each S spent on the program and criterion tests was maintained by the class teacher.

After eight 50-minute periods of study all students were given the questionnaire which was followed immediately by a parallel form of the criterion test administered to each S whether he had completed the program or not.

Two weeks after completing the permutations and combinations program, the sets program was given, this time Class II working under linear conditions and Class I under self-directed conditions. Administrative and testing procedure was the same as that used for the permutations and combinations program. The sets criterion tests were of the same general form as the permutations and combinations criterion tests except that there were only 33 items (criterion tests for both topics are shown in appendix B).

Four to six weeks following completion of each program, the criterion test was given again in order to obtain retention measures.

Results

A type II analysis of variance (Lindquist, 1953) of final criterion test scores revealed no significant effect of teaching method. Nor was the method-by-lesson interaction significant. Mean final test score for self-directed study (summed across lessons) was 25.7 as compared with 25.5 for linear study.

Retention test results for both programs revealed no systematic effect of teaching method on retention. For the permutations and combinations program, the mean retention test scores for self-directed and linear groups were 28.9 and 29.6 respectively. On the sets retention test, these means were 14.2 for self-directed and 16.1 for linear Ss.

Time spent studying (total time less time spent in taking tests) was 8% less for self-directed Ss than for linear Ss. However, if the time that Ss spent in taking tests (preceding the final criterion test) is added to study time, the means for the two conditions are virtually identical (291 minutes for self-directed, 286 minutes for linear).

Table 1 presents correlations of ability, performance, and time variables for linear and self-directed conditions. The mathematics grades used in these correlations were obtained by summing the scores each student obtained on all tests given by the class teacher prior to beginning the experiment. The significance of the difference between self-directed and linear correlations was tested using the z transformation. The difference between correlations of test score and study time for self-directed and linear conditions fell just short of significance at the .05 level.

Table 1

Correlations of Performance, Time, and Ability Data Combined Across Lessons

	Differential Aptitude Numerical Subtest	Final Test Score	Study Time
Mathematics Grades			
Self-directed	.58	.62	-.01
Linear		.48	.19
Differential Aptitude Numerical Subtest			
Self-directed		.58	.14
Linear		.05	-.31
Final Test Score			
Self-directed			.17
Linear			.55

*Difference significant at .05 level.

Under each condition (self-directed and linear) 29 Ss took one or more tests prior to the final criterion. However, in the self-directed condition, 16 Ss took the test two or more times while only 6 Ss did so in the linear condition. The mean mathematics score for those Ss who took one or more tests prior to the criterion test was 323 while the mean for the Ss who did not take any tests prior to the criterion was 147. Thus it appears that Ss of relatively low ability were able to recognize that they were not ready to take a test on the material and did not do so until they were forced to.

In analyzing the data from the questionnaire, responses to the first item were scored and a type II analysis of variance was performed. This questionnaire item asked Ss to rate the lesson they had just completed on how much they enjoyed studying it. The teaching method main effect was significant ($F = 8.59$, 1 and 36 df, $p < .01$) with the linear condition preferred to the self-directed for both lessons. The main effect of lesson and the interaction were not significant.

When the questionnaire was given following the sets program (by this time, Ss had had experience with both linear and self-directed conditions) an item was included which asked Ss to rate on a five-point scale how they liked the method they used to study sets as compared with the method they used in the permutations program. A rating of five indicated that they preferred the sets method much more than the permutations method. A rating of three meant equal preference. The mean rating for Ss who had studied sets under linear conditions was 4.3 while the mean for Ss who studied under self-directed conditions was 3.6. The correlation of this item with final test score for Ss who studied sets under linear conditions was .31. For Ss under self-directed conditions, the correlation was .46. The correlation between DAT and preference for the sets method of study was .43 for Ss who studied sets under self-directed conditions and .17 for Ss under linear conditions. The difference between these two correlations is in the direction that would suggest that the more able students prefer self-direction while the poorer students prefer linear study.

Responses to the questionnaire by Ss who had just completed studying under self-directing conditions indicated that students in general appeared to want more self-test questions and examples and explanations of

concepts in the program. Those Ss who indicated a preference for fewer types of study materials scored significantly lower ($p < .001$) on the criterion test than Ss who preferred more materials. The mean mathematics grade for these Ss was also significantly lower ($p < .02$) than the mean for Ss expressing a desire for more types or quantity of materials. Approximately one half of these low-scoring Ss indicated that they preferred having the materials put in a certain required order instead of having to organize the material on their own. (See appendix for response frequencies to questionnaire items.)

Discussion

The data show that the use of self-directing and self-evaluating techniques does not produce more efficient or superior learning of mathematics as compared with linear programing procedures, at least for students of the age and ability level used in this study. However, the fact that giving these students more responsibility for the learning process did not adversely affect their performance is encouraging in itself.

By the time students are in the ninth grade, they have developed a strong habit of linear study methods, and this may have worked against the effectiveness of self-direction in the present experiment. The materials and teaching methods that have been typically used in the classroom are well structured and it is in relatively rare instances that students are encouraged to organize their own materials and study procedure. The Ss' preference for linear methods (as evidenced by the analysis of questionnaire responses) may also stem partly from this well-developed habit and their long experience with structured course work. It is conceivable that self-directing methods may prove more effective if initiated in lower grade levels. Also, some degree of coaching or pretraining in the use of self-directing materials might be effective.

With respect to the DAT and final test score correlations, it appears that linear programing reduces or eliminates the dependence of learning upon ability, a result not inconsistent with results of other studies (e.g. Meyer, 1960). However, in previous studies (Campbell, 1962) using this same program in a more concise linear form allowing less than half as much time to cover the same objectives, the correlations between DAT

and posttest scores were about .50. This suggests that amount learned correlates strongly with ability only when the learning method demands relatively rapid assimilation of new knowledge.

References

Campbell, V. N. Studies of bypassing as a way of adapting self-instruction programs to individual differences. San Mateo, California: American Institute for Research, May, 1962. AIR-C41-5/62-FR.

Campbell, V. N. and Terry, D. F. Permutations and combinations: an experimental learning program. Palo Alto: American Institute for Research, March, 1963. AIR-D10-3/63-RP.

Campbell, V. N., Terry, D. F. and Shearer, J. W. Some basic concepts of set theory. San Mateo, California: American Institute for Research, May 1962. AIR-C41-4/62-RP.

Lindquist, E. F. Design and analysis of experiments in psychology and education. Cambridge: The Riverside Press, 1953.

Meyer, S. R. Report on the initial test of a junior high school vocabulary program. In A. A. Lumsdaine and R. Glaser (Eds.), Teaching machines and programmed learning. Washington, D. C.: National Education Association of the United States, 1960. pp. 229-246.

APPENDIX A

Questionnaires and distribution of responses to questionnaire items

Questionnaire given students upon completion of permutations and combinations lesson under linear conditions.

Questionnaire on the Permutations and Combinations Lesson

Please answer the following questions frankly. Your answers will NOT affect your grades in any way. The information you give us will help us revise the lesson for other classes of students next year. For each question check only one answer unless other instructions are given. If no answer fits, write your own answer or other comment in the space to the right.

1. How much did you enjoy studying permutations and combinations?

3	liked it very much	other answer or comment:
5	liked it	
1	liked it a little	
5	neutral	
2	disliked it a little	
1	disliked it	
1	disliked it very much	

2. Would you be interested in learning more about permutations, combinations or other kinds of counting problems?

1	definitely yes	other answer or comment:
7	yes, I think so	
7	could take it or leave it	
2	no, I don't think so	
1	definitely not	

3. How often did you wish you could stop and get more explanation or examples of a certain idea, instead of going straight on through the chapter?

7	many times a day	other answer or comment:
8	a few times a day	
3	once or twice a day	
0	less than once a day	
0	never	

4. What changes in the lesson would you suggest before we give it to other students? (Check as many answers as you want)

7	give the students more choice as to <u>how</u> they study	other answer or comment:
5	more questions to answer	
0	fewer questions to answer	
9	more worked out examples	
1	fewer worked out examples	
9	more general explanation in the text	
2	less general explanation in the text	
5	more help from the teacher	
2	more work space on chair or desk	

Questionnaire given students upon completion of permutations and combinations lesson under self-directing conditions.

Questionnaire on the Permutations and Combinations Lesson

Please answer the following questions frankly. Your answers will NOT affect your grades in any way. The information you give us will help us revise the lesson for other classes of students next year. For each question check only one answer unless other instructions are given. If no answer fits, write your own answer or other comment in the space to the right.

1. How much did you enjoy studying permutations and combinations?

		other answer or comment:
3	liked it very much	
2	liked it	
1	liked it a little	
5	neutral	
3	disliked it a little	
6	disliked it	
3	disliked it very much	

2. Would you be interested in learning more about permutations, combinations or other kinds of counting problems?

		other answer or comment:
2	definitely yes	
4	yes, I think so	
9	could take it or leave it	
6	no, I don't think so	
2	definitely not	

3. Listed below are the four types of materials in the lesson. Place a 1 in the blank beside the material from which you learned the most. Place a 2 beside the one from which you learned the 2nd most. Place a 3 beside the one from which you learned the 3rd most. Place a 4 beside the material from which you learned the least.

3.57	Outline	comment:
1.71	Text (green covers)	
2.48	Examples and Explanations (pink covers)	
2.00	Self-test items (yellow covers)	

MEAN
RANK

4. Listed below are the four types of materials in the lesson. Place a 1 in the blank beside the material you spent the most time on. Place a 2 beside the one you spent next most time on. Place a 3 beside the one you spent third most time on. Place a 4 in the blank next to the material you spent the least time on.

3.73	Outline	comment:
1.87	Text (green covers)	
2.64	Examples and Explanations (pink covers)	
1.70	Self-test items (yellow covers)	

MEAN
RANK

5. Which procedure did you use in studying the lesson?

5	read all of one type of materials (that is, all of the same color) before going on to a different type	other answer or comment:
11	read all types of materials on one idea (that is, all materials falling under a certain capital letter) before going on to the next idea or letter	
6	followed no particular procedure	
1	followed a procedure different than those described above. (If you check this answer, describe the procedure used in the space at the right.)	

6. On the average, how often did you use the capital letters as an index to other materials?

5	many times a day	other answer or comment:
5	a few times a day	
6	once or twice a day	
3	less than once a day	
4	never	

7. If you couldn't understand something, did you stop and look for other materials covering the same idea?

1	no	other answer or comment:
0	not usually	
7	sometimes	
8	most of time	
7	always	

8. Did you have difficulty deciding what to do next?

7	no	other answer or comment?
5	only at first	
10	sometimes	
0	usually	
1	always	

9. How much did you improve at organizing your own study between the first day on this lesson and the last day?

4	none	other answer or comment:
2	just a little	
7	some	
10	a great deal	

10. How did you decide when to take the test for the first time?
(check one or more answers)

2	asked other students who had taken it how hard it was
6	judged by whether I could answer self-test questions (in yellow booklets)
1	studied until I could answer the sample questions on the <u>outline</u>
8	studied until I felt I knew all the main ideas
9	I ran out of time and had to take the test

other answer or comment:

11. Did you change your method of study after taking the test the first time?

3	yes —— If your answer is <u>yes</u>, what did you do differently?
9	no
11	didn't study any more after the first test

(answer here)

12. What changes in the lesson would you suggest before we give it to other students? (Check as many answers as you want.)

7	put all the materials in a certain required order instead of having the students choose on their own
9	more self-test questions
8	more explanations and examples
10	more help from the teacher
5	not so many different study materials
5	more work space on chair or desk

_____ other answer or comment:

Questionnaire given students upon completion of sets lesson under linear conditions.

Questionnaire on the Sets Lesson

Please answer the following questions frankly. Your answers will NOT affect your grades in any way. The information you give us will help us revise the lesson for other classes of students next year. For each question check only one answer unless other instructions are given. If no answer fits, write your own answer or other comment in the space to the right.

1. How much did you enjoy studying sets?

1	liked it very much	other answer or comment:
6	liked it	
2	liked it a little	
7	neutral	
2	disliked it a little	
3	disliked it	
0	disliked it very much	

2. Would you be interested in learning more about sets?

0	definitely yes	other answer or comment:
4	yes, I think so	
10	could take it or leave it	
5	no, I don't think so	
2	definitely not	

3. How often did you wish you could stop and get more explanation or examples of a certain idea, instead of going straight on through the chapter?

6	many times a day	other answer or comment:
2	a few times a day	1
7	once or twice a day	
2	less than once a day	
3	never	

4. What changes in the lesson would you suggest before we give it to other students? (Check as many answers as you want)

9	give the students more choice as to <u>how</u> they study	other answer or comment:
9	more questions to answer	4
1	fewer questions to answer	
13	more worked out examples	
0	fewer worked out examples	
9	more general explanation in the text	
0	less general explanation in the text	
9	more help from the teacher	
6	more work space on chair or desk	

5. Which lesson topic did you like best?

		other answer or comment:
4	permutations and combinations	
16	sets	1

6. How did you like the method you used to study sets as compared with the way you studied permutations and combinations?

		other answer or comment:
9	much better than the permutations and combination method	
5	better than the permutations and combinations method	
4	same as the permutations and combinations method	
2	worse than the permutations and combinations method	
1	much worse than the permutations and combinations method	

7. If, in the next topic you study, you were given a choice of which study method to use, which one would you prefer?

		other answer or comment:
5	permutations and combinations lesson method	
15	sets lesson method	1

8. Would you always select the method you checked above no matter what the subject was you were studying?

		other answer or comment:
10	yes	
10	no	1

9. Suppose you were studying something at home because you were interested in it, NOT because your teacher told you to study it. Which method would you choose then?

4	permutations and combinations lesson method	other answer or comment:
15	sets lesson method	

Questionnaire given students upon completion of sets lesson under self-directing conditions.

Questionnaire on the Sets Lesson

Please answer the following questions frankly. Your answers will NOT affect your grades in any way. The information you give us will help us revise the lesson for other classes of students next year. For each question check only one answer unless other instructions are given. If no answer fits, write you own answer or other comment in the space to the right.

1. How much did you enjoy studying sets?

2	liked it very much	other answer or comment:
2	liked it	
2	liked it a little	
3	neutral	
4	disliked it a little	
3	disliked it	
2	disliked it very much	

2. Would you be interested in learning more about sets?

1	definitely yes	other answer or comment:
4	yes, I think so	
4	could take it or leave it	
5	no, I don't think so	
4	definitely not	

3. Listed below are the four types of materials in the lesson. Place a 1 in the blank beside the material from which you learned the most. Place a 2 beside the one from which you learned the 2nd most. Place a 3 beside the one from which you learned the 3rd most. Place a 4 beside the material from which you learned the least.

	2.12	Outline
	2.29	Text (green covers)
MEAN		Examples and Explanations
RANK	2.19	(pink covers)
		Self-test items (yellow
	2.38	covers)

comment:

4. Listed below are the four types of materials in the lesson. Place a 1 in the blank beside the material you spent the most time on. Place a 2 beside the one you spent next most time on. Place a 3 beside the one you spent third most time on. Place a 4 in the blank next to the material you spent the least time on.

	2.88	Outline
	2.06	Text (green covers)
MEAN		Examples and Explanations
RANK	2.94	(pink covers)
		Self-test items (yellow
	2.12	covers)

comments:

5. Which procedure did you use in studying the lesson?

3	read all of one type of materials (that is, all of the same color) before going on to a different type	other answer or comment:
4	read all types of materials on one idea (that is, all materials falling under a certain number) before going on to the next idea or number	
9	followed no particular procedure	
2	followed a procedure different than those described above. (If you check this answer, describe the procedure used in the space at the right.)	

6. On the average, how often did you use the numbers as an index to other materials?

4	many times a day	other answer or comment:
4	a few times a day	
2	once or twice a day	
4	less than once a day	
3	never	

7. If you couldn't understand something, did you stop and look for other materials covering the same idea?

1	no	other answer or comment:
0	not usually	
6	sometimes	
5	most of time	
5	always	

8. Did you have difficulty deciding what to do next?

6	no
5	only at first
6	sometimes
0	usually
1	always

other answer or comment:

9. How much did you improve at organizing your own study between the first day on this lesson and the last day?

0	none
3	just a little
13	some
2	a great deal

other answer or comment:

10. How did you decide when to take the test for the first time? (check one or more answers)

2	asked other students who had taken it how hard it was
2	judged by whether I could answer self-test questions (in yellow booklets)
3	studied until I could answer the sample questions on the <u>out-line</u>
13	studied until I felt I knew all the main ideas
2	I ran out of time and had to take the test

other answer or comment:

11. Did you change your method of study after taking the test the first time?

4	yes	If your answer is yes, what did you do differently? (answer here)
12	no	
0	didn't study any more after the first test	

12. What changes in the lesson would you suggest before we give it to other students? (check as many answers as you want.)

6	put all the materials in a certain required order instead of having the students choose on their own
9	more self-test questions
5	more explanations and examples
5	more help from the teacher
4	not so many different study materials
5	more work space on chair or desk

other answer or comment:
3

13. Which lesson topic did you like best?

7	permutations and combinations	other answer or comment: 3
8	sets	

14. How did you like the method you used to study sets as compared with the way you studied permutation and combinations?

6	much better than the permutations and combinations method	other answer or comment: 1
3	better than the permutations and combinations method	
5	same as the permutations and combinations method	
2	worse than the permutations and combinations method	
1	much worse than the permutations and combinations method	

15. If, in the next topic you study, you were given a choice of which study method to use, which one would you prefer?

7	permutations and combinations lesson method	other answer or comment: 1
10	sets lesson method	

16. Would you always select the method you checked above no matter what the subject was you were studying?

11	yes	other answer or comment:
7	no	

17. Suppose you were studying something at home because you were interested in it, NOT because your teacher told you to study it. Which method would you choose then?

8	permutations and combinations lesson method	other answer or comment:
10	sets lesson method	

APPENDIX B

Criterion tests for permutations and combinations and sets lessons

Name _____

Date _____

TEST ON PERMUTATIONS AND COMBINATIONS

1. If you were asked to rank your choices of the 6 colors of the rainbow,

   a) in how many different ways could you make your first choice? _____

   b) After you have made your first choice, how many ways are there for making your second choice?

   _____

   c) How many different ways can you make a first and second choice together?

   _____

2. a) If $2 \times n = 6$, what does n equal? _____

   b) If $n = 32$, what does $(n-2)$ equal? _____

   c) If $n \times (n-1) = 12$, what does n equal? _____

3. Larry decided he liked Sally best, Louise next best, and Arline best after that. Show that this permutation of Larry's preferences is a one-to-one matching by writing or drawing an illustration.

4. Show one of the possible one-to-one matchings of apples, pears, bananas, and oranges with the signs +, x, $, and %.

5. a) How many permutations of t objects are there? _____

b) Give a numerical answer to part (a) for t = 7. _____

6.

Seven simple figures are drawn above. If we choose △ , □ and ∩ without regard to order we have an example of a combination of n things taken r at a time. That is, n = _____ and r = _____.

Putting these 3 figures in a certain order, as shown below gives us a _____ permutation of 7 things taken _____ (number) at a time.

1st 2nd 3rd

△ □ ∩

1st 2nd 3rd

△ ✳ ⬡ This is not only a different

_____ _____ from the one shown just above but also a different _____.

7. n! means n _____. (write one word in the blank)

8. Show how to count the number of different permutations of 5 objects by filling as many (maybe not all) of the spaces below as you need.

____ x ____ x ____ x ____ x ____ x ____ x ____ = ____

9. On a particular decision of the U. S. Supreme Court three of the Justices disagreed with the majority opinion. Not knowing which 3 men disagreed, how many different combinations of 3 men could it have been? (There are 9 Justices of the Supreme Court.)

10. Write down 2 different permutations of the first 4 letters of the alphabet.

11. At right is the set of ten numerals used in the Arabic number system. Below is one combination of these numerals, a combination having how many members?

1, 2, 3, 4, 5, 6, 7, 8, 9, 0

_____

1, 2, 3, 4, 5, 6, 7

In how many different permutations could members of this combination be arranged?

_____

In this example r = _____, n = _____.

12. a) A home owner has bought six different rugs for 6 rooms in his house. If he picks one out of the 6 for the living room before he picks a rug for any other room, how many ways are there of picking a rug for the living room?

_____

b) Then in how many ways can he pick a rug for the dining room after the living room rug has been picked?

_____

c) In how many different ways can he put his 6 rugs in 6 rooms?

13. Suppose you are going to select combinations of 5 letters using any of the 26 letters of the alphabet. In the space beside each bracket below, write "same" if the two sets of 5 letters represent the same combination. Write "no" if they are not the same combination.

(a) _____ {A, B, C, D, E / F, G, H, I, J}

(b) _____ {F, G, H, I, J / I, J, K, L, M}

(c) _____ {I, J, K, L, M / M, L, K, J, I}

(d) _____ {T, R, S, P, Q / P, S, Q, T, R}

(e) _____ {A, B, C, D, E / Z, B, C, D, E}

(f) _____ {A, B, C, D, E / B, C, D, E, F}

14. a) Suppose you wrote down all the partial permutations of n letters taken r at a time. If r equaled 4, how many of the partial permutations you wrote down would use the same combination of letters?

_____

b) If there are 5 combinations of n letters taken 4 at a time, what does n equal?

_____

15. a) A young girl has 7 colors of paint and seven different toys to paint. How many different ways can she decide which toys she will paint which color, if each toy is to be painted a different color?

b) If she feels that 3 of the toys don't need painting, how many different ways can she decide which colors to paint the remaining 4 toys (each one a different color), if she still has a choice of 7 colors?

16. How many different one-to-one matchings are there between 2 sets of objects if there are 10 objects in each set?

_____

17. The number of different ways 7 brothers could marry 7 sisters is the same as

a) the number of combinations of 14 things taken 7 at a time.

b) the number of partial permutations of 14 things taken 7 at a time.

c) the number of permutations of 7 things.

d) the number of permutations of 14 things.

18. Below is a list of all the partial permutations of 5 letters (A, B, C, D, E) taken 2 at a time.

AB	BA	CA	DA	EA
AC	BC	CB	DB	EB
AD	BD	CD	DC	EC
AE	BE	CE	DE	ED

Suppose we were to divide these into <u>groups</u> according to which letters were used. Then all the partial permutations in one <u>group</u> would use the exact same letters.

In other words each group would represent a different

_____ of letters.

19. Following are several counting problems. In the left-hand blank below each problem name <u>what</u> the problem asks you to count --- "permutations" (for one-to-one matchings write "permutations" also), "partial permutations," or "combinations." If the problem does not involve counting any of these 3, put a check mark (✓). In the right-hand blank enter the answer. Abbreviate when possible. The first 2 are completed as examples.

(a) Nine boys decide to form a baseball team. They want to select their pitcher first and then their catcher. How many different ways can they select the pitcher-catcher pair?

partial permutations — (What you are to count)

9 × 8 (or 72) — (Answer)

(b) If there are 200 people on a train and each car has 20 people in it, how many cars does the train have?

✓ — (What you are to count)

10 — (Answer)

(c) If you were given a test with 5 problems and were told to work any 3 of them, in how many ways could you select which problems to do on the test?

_____ — (What you are to count)

_____ — (Answer)

(d) Grandma took the lids off all her jam jars and filled the jars with jam. Since she paid no attention to which lid came from which jar (all lids being the same size), in how many different ways could she put the 6 lids back on the 6 jars?

_____ — (What you are to count)

_____ — (Answer)

(e) The Belchfire-8 car offers 3 different engines which can be used in any of 5 different bodies. How many different cars can the buyer choose from?

_____ _____

(What you are to count) (Answer)

(f) A magician handed someone a deck of 52 cards to shuffle and said he could predict accurately which card would be on top, which card would be second in the deck and which card would be third.

The particular arrangement of 3 cards named by the magician is just one out of how many different arrangements that could occur by chance?

_____ _____

(What you are to count) (Answer)

(g) In how many different ways can k birds line up on a wire?

_____ _____

(What you are to count) (Answer)

(h) A Genini space capsule will carry 2 astronauts. Six men volunteered for the crew of the Gemini capsule. How many different 2-man crews can be selected from 6 volunteers?

_____ _____

(What you are to count) (Answer)

(i) A chimpanzee sits down at the typewriter to try to write a novel and pecks out five letters. If he never hit the same letter twice, how many different words could have resulted? (Nonsense or not, that is, bxghl would be a word.)

_____ _____

(What you are to count) (Answer)

(j) A woman has c hats and d dresses. If she can wear any hat with any dress, how many different outfits (an outfit is a hat and a dress) does she have to choose from?

_____ _____

(What you are to count) (Answer)

(k) There are 52 cards in an ordinary deck of cards, and each one is different. If you were playing a card game in which you were dealt 5 cards, how many different hands could you be dealt?

_____ _____

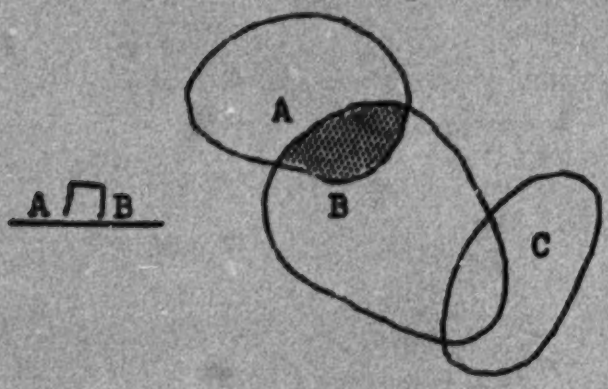
(What you are to count) (Answer)

Name _____

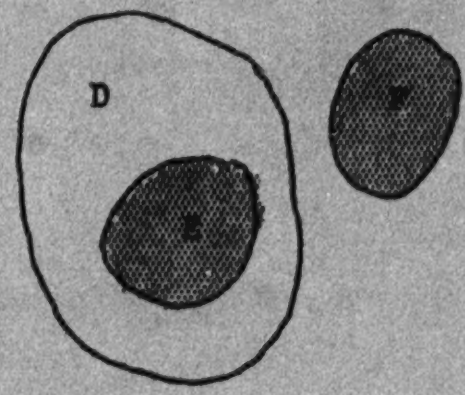
This is a quiz to see how much you learned about sets. Work rapidly. Skip questions you can't answer and come back to them later if there is time. Guess if you are still not sure of an answer. You may write or draw anywhere on this booklet.

TURN THE PAGE AND BEGIN.

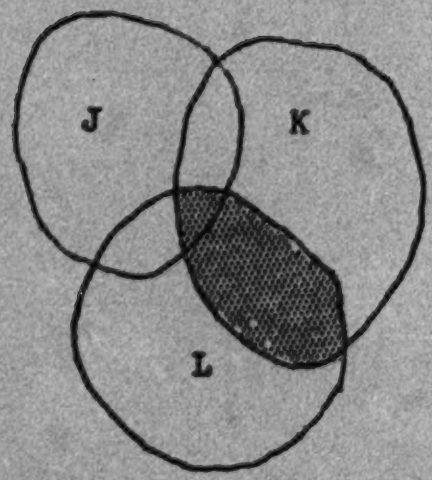
I. At the left of each picture, write <u>in signs</u> what the <u>shaded</u> part of the picture is. The first two answers are given as examples. Notice that in each picture one of the sets is not needed to describe the shaded area. Use only letters and these two signs where needed: $\sqcap$, $\sqcup$ (and parentheses where needed).



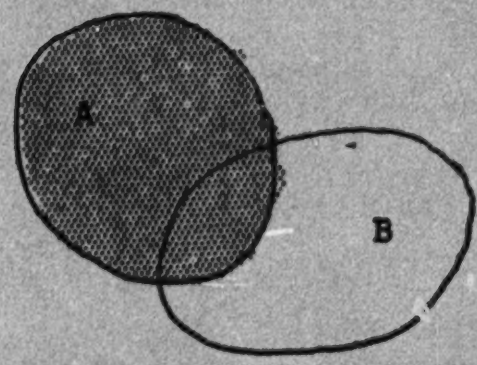
$A \sqcap B$



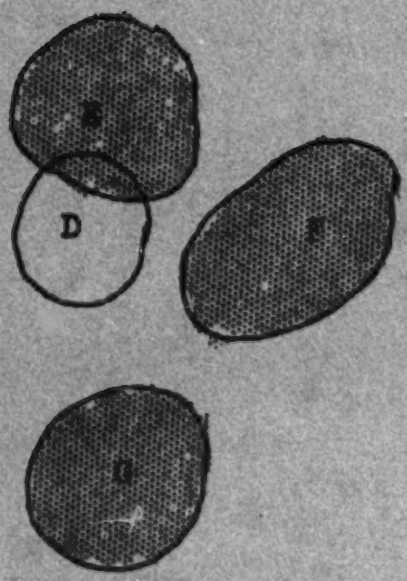
$E \sqcup F$



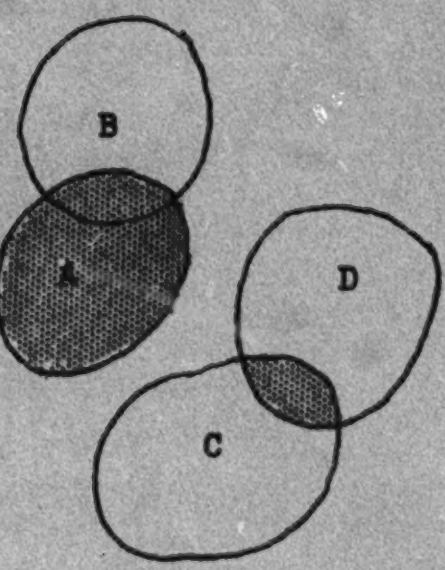
_____



_____



_____



_____

II. Definitions (Fill in the blanks).

a. If every element of Set A is also an element of Set B, then A is a _____ of B.

b. The part of Set A which is also in Set B is called the _____ of Sets A and B.

c. That set which is made up of all the elements in Set F and all the elements in Set G is called the _____ of Sets F and G.

III. In signs, write

a. Union of Sets C and D _____

b. Intersection of Sets C and D _____

c. D is a subset of C _____

d. The union of Set C with the intersection of D and E.

_____

e. The intersection of Sets C and D is a subset of the union of Sets C and D. _____

IV. In the list of words shown at right,

Set A = names of trees

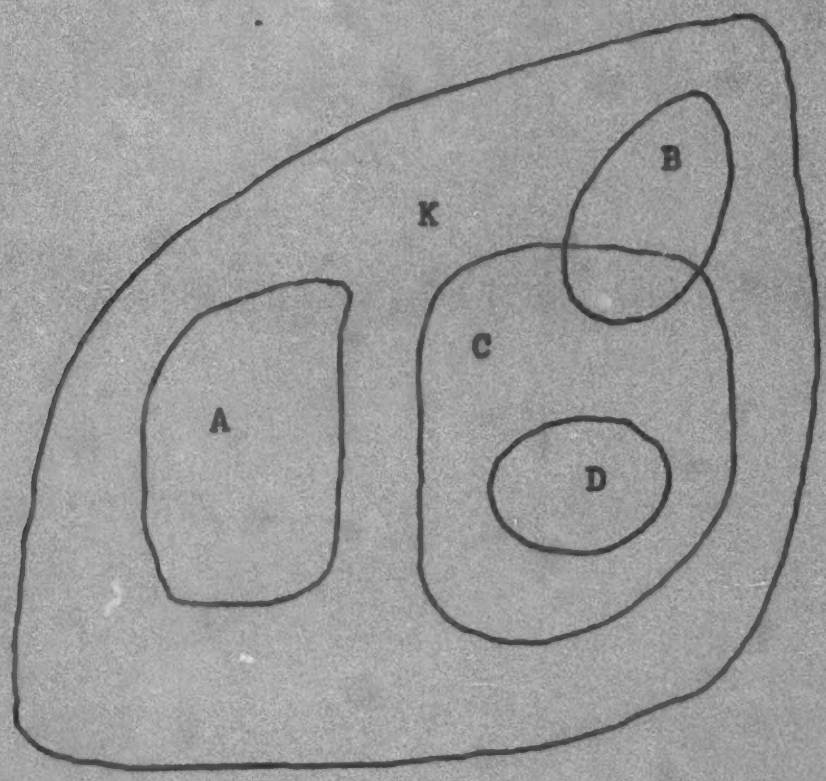
Set B = words beginning with vowels (a, e, i, o, u.)

In the list at right, underline all words belonging to the union of Sets A and B.

pine
eat
groceries
elm
oak
redwood
upper

In the space below, write the words belonging to the intersection of Sets A and B.

V. Below are several statements in signs about the picture at the right. Circle the <u>true</u> statements.



$D \sqsubset C$

$C \sqsubset D$

$B \sqsubset C$

$D \sqsubset K$

$A \sqsubset B$

$(A \sqcup B) \sqsubset K$

$(B \sqcup D) \sqsubset C$

$(B \sqcap C) \sqsubset B$

$(B \sqcap C) \sqsubset (B \sqcup C)$

$A \sqsubset (B \sqcap K)$

$A \sqsubset (B \sqcup K)$

$C \sqsubset (A \sqcup B \sqcup D)$

$(B \sqcap C \sqcap K) \sqsubset D$

$(B \sqcap C \sqcap K) \sqsubset (C \sqcup A)$

VI.

Set W = Wild animals

Set M = Male animals

Set L = Lions

Set R = Roosters

Write in signs what the following sets are (the first 3 are given as examples):

1. all male lions $M \sqcap L$
2. all animals which are either wild or male (or both) $W \sqcup M$
3. all animals which are either roosters or male lions $R \sqcup (M \sqcap L)$
4. all male wild animals
5. all animals which are either lions or males (or both) _____
6. all animals which are either wild or roosters _____
7. all male animals which are either wild or roosters _____
8. all wild male lions _____
9. all animals which are either roosters or male lions _____

Write the following statements in signs (the first 2 are given as examples):

10. All roosters are male animals. $R \sqsubset M$
11. All male wild animals are wild. $(M \sqcap W) \sqsubset W$
12. All lions are wild animals. _____
13. All male lions are wild animals. _____
14. All lions are either male or wild (or both). _____
15. All male lions are either wild animals or roosters. _____